1.

(a) $a(2) = v'(2) = 1.587$ or 1.588 $v(2) = -3\sin(2) < 0$ Speed is decreasing since $a(2) > 0$ and $v(2) < 0$.	$2 : \begin{cases} 1: & a(2) \\ 1: & \text{speed decreasing with reason} \end{cases}$
(b) $v(t) = 0$ when $\dfrac{t^2}{2} = \pi$ $t = \sqrt{2\pi}$ or 2.506 or 2.507 Since $v(t) < 0$ for $0 < t < \sqrt{2\pi}$ and $v(t) > 0$ for $\sqrt{2\pi} < t < 3$, the particle changes directions at $t = \sqrt{2\pi}$.	$2 : \begin{cases} 1: & t = \sqrt{2\pi} \text{ only} \\ 1: & \text{justification} \end{cases}$
(c) Distance $= \int_0^3 \lvert v(t) \rvert \, dt = 4.333$ or 4.334	$3 : \begin{cases} 1: & \text{limits} \\ 1: & \text{integrand} \\ 1: & \text{answer} \end{cases}$
(d) $\int_0^{\sqrt{2\pi}} v(t)\, dt = -3.265$ $x\left(\sqrt{2\pi}\right) = x(0) + \int_0^{\sqrt{2\pi}} v(t)\, dt = -2.265$ Since the total distance from $t = 0$ to $t = 3$ is 4.334, the particle is still to the left of the origin at $t = 3$. Hence the greatest distance from the origin is 2.265.	$2 : \begin{cases} 1: & \pm \text{ (distance particle travels while velocity is negative)} \\ 1: & \text{answer} \end{cases}$

2.

(a) $a(2) = v'(2) = -0.132$ or -0.133	1 : answer
(b) $v(2) = -0.436$ Speed is increasing since $a(2) < 0$ and $v(2) < 0$.	1 : answer with reason
(c) $v(t) = 0$ when $\tan^{-1}\left(e^t\right) = 1$ $t = \ln(\tan(1)) = 0.443$ is the only critical value for y. $v(t) > 0$ for $0 < t < \ln(\tan(1))$ $v(t) < 0$ for $t > \ln(\tan(1))$ $y(t)$ has an absolute maximum at $t = 0.443$.	$3 : \begin{cases} 1 : \text{sets } v(t) = 0 \\ 1 : \text{identifies } t = 0.443 \text{ as a candidate} \\ 1 : \text{justifies absolute maximum} \end{cases}$
(d) $y(2) = -1 + \int_0^2 v(t)\,dt = -1.360$ or -1.361 The particle is moving away from the origin since $v(2) < 0$ and $y(2) < 0$.	$4 : \begin{cases} 1 : \int_0^2 v(t)\,dt \\ 1 : \text{handles initial condition} \\ 1 : \text{value of } y(2) \\ 1 : \text{answer with reason} \end{cases}$

3.

(a) $\int_0^{24} v(t)\,dt = \frac{1}{2}(4)(20) + (12)(20) + \frac{1}{2}(8)(20) = 360$ The car travels 360 meters in these 24 seconds.	$2: \begin{cases} 1: \text{value} \\ 1: \text{meaning with units} \end{cases}$
(b) $v'(4)$ does not exist because $\lim_{t\to 4^-}\left(\frac{v(t)-v(4)}{t-4}\right) = 5 \neq 0 = \lim_{t\to 4^+}\left(\frac{v(t)-v(4)}{t-4}\right).$ $v'(20) = \frac{20-0}{16-24} = -\frac{5}{2}\ \text{m/sec}^2$	$3: \begin{cases} 1: v'(4) \text{ does not exist, with explanation} \\ 1: v'(20) \\ 1: \text{units} \end{cases}$
(c) $a(t) = \begin{cases} 5 & \text{if } 0 < t < 4 \\ 0 & \text{if } 4 < t < 16 \\ -\frac{5}{2} & \text{if } 16 < t < 24 \end{cases}$ $a(t)$ does not exist at $t = 4$ and $t = 16$.	$2: \begin{cases} 1: \text{finds the values } 5, 0, -\frac{5}{2} \\ 1: \text{identifies constants with correct intervals} \end{cases}$
(d) The average rate of change of v on $[8, 20]$ is $\frac{v(20)-v(8)}{20-8} = -\frac{5}{6}\ \text{m/sec}^2.$ No, the Mean Value Theorem does not apply to v on $[8, 20]$ because v is not differentiable at $t = 16$.	$2: \begin{cases} 1: \text{average rate of change of } v \text{ on } [8, 20] \\ 1: \text{answer with explanation} \end{cases}$

4.

(a) $a(4) = v'(4) = \frac{5}{7}$

1 : answer

(b) $v(t) = 0$

$t^2 - 3t + 3 = 1$

$t^2 - 3t + 2 = 0$

$(t-2)(t-1) = 0$

$t = 1, 2$

$v(t) > 0$ for $0 < t < 1$

$v(t) < 0$ for $1 < t < 2$

$v(t) > 0$ for $2 < t < 5$

The particle changes direction when $t = 1$ and $t = 2$.
The particle travels to the left when $1 < t < 2$.

3 : { 1 : sets $v(t) = 0$; 1 : direction change at $t = 1, 2$; 1 : interval with reason }

(c) $s(t) = s(0) + \int_0^t \ln\left(u^2 - 3u + 3\right) du$

$s(2) = 8 + \int_0^2 \ln\left(u^2 - 3u + 3\right) du$

$= 8.368$ or 8.369

3 : { 1 : $\int_0^2 \ln\left(u^2 - 3u + 3\right) du$; 1 : handles initial condition; 1 : answer }

(d) $\frac{1}{2}\int_0^2 |v(t)|\, dt = 0.370$ or 0.371

2 : { 1 : integral; 1 : answer }